The UK Wind Resource
Capacity Factor and Diversity

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Introduction

Wind power exhibits distinct seasonal patterns in the UK – onshore wind speeds are typically higher in winter than in summer, while on average wind speeds are higher during the afternoon and evening than during overnight or morning periods.

These long term patterns of wind availability broadly coincide with patterns of electricity demand in the UK. Yet within these seasonal patterns there remains hour to hour variability in wind power between different locations.

By establishing wind farms in a range of geographically distinct locations, these different wind power supply patterns can be harnessed to provide an aggregate wind power supply that exhibits less hour to hour variability.

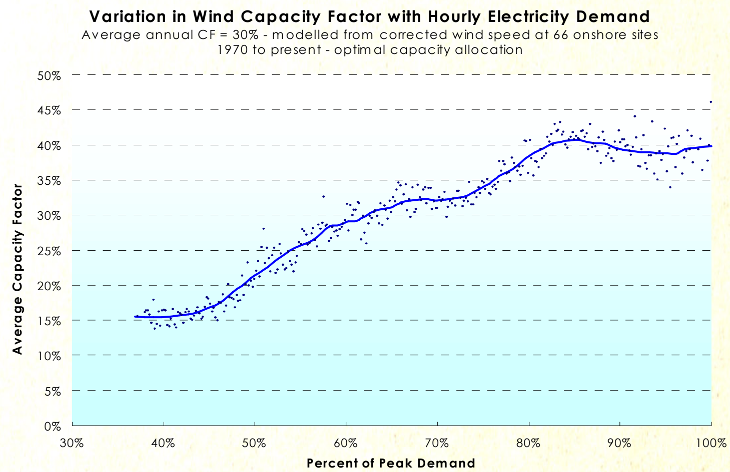
Presented here are two key features of the UK wind resource – firstly, that wind power contributes more at times of peak demand, and secondly that a diversified pattern of wind power development acts to smooth the aggregate supply profile.

Capacity Factor and Hourly Electricity Demand

Capacity factor is used as a measure of the actual output of a generator compared to its theoretical maximum output from operating at maximum (or rated) capacity. The capacity factor of the UK wind resource is commonly given as a single figure, typically representing the annual average. However, the seasonal variability of the UK wind resource means that the average capacity factor for wind power changes during the year. In a similar manner, electricity demand shows seasonal, together with hourly, changes in demand.

The figure to the right shows the average hourly capacity factor for a diversified UK wind power supply against hourly electricity demand. This figure demonstrates that wind power in the UK is more effective at supplying electricity during periods of peak electricity demand; the capacity factor for wind power averages around 40% when demand is within 20% of peak, dropping to less than 20% for the lowest 12% of demand hours.

This finding has implications for the backup requirements associated with wind power. As the capacity value of wind power is closely linked to its capacity factor, these findings suggests that the greatest potential for wind to displace conventional generating capacity occurs during periods of peak demand. At other times, the low capacity factor of wind power will have little or no impact on backup requirements, as there is surplus generating capacity already available.



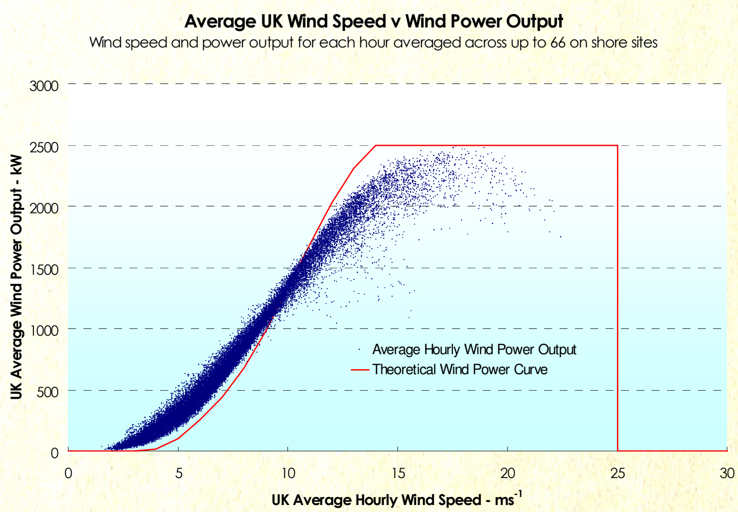
The Smoothing Effect of Diversification

The general power transform function for a typical wind turbine is well known, with key features being a minimum cut-in speed (typically around $4ms^{-1}$) and cut-out speed (typically around $25ms^{-1}$). Output from an individual wind turbine may conform to this transform function – however, in a system where wind generating capacity is installed in a diverse range of geographic locations, the aggregate response of the wind portfolio is altered.

The figure to the right shows the modelled average hourly output from a diversified range of wind farms against the average hourly wind speed for the UK (32,000 randomly selected hours between 1970-2003). This figure demonstrates that a diversified system smoothes the overall power output characteristics of wind power.

At average hourly wind speeds of $<10ms^{-1}$ (accounting for over 80% of all hours), output is higher than that for a single turbine or location, with electricity generation continuing during low wind periods when average wind speeds can drop below $4ms^{-1}$. At high wind speeds this smoothing effect is also apparent - while the $25ms^{-1}$ cut-out criteria will occur at individual locations, this never occurs across the whole of the UK at one time.

This smoothing effect occurs when wind power is developed in a range of locations. However, through understanding the different patterns of wind power availability in different parts of the UK, an optimal allocation of generating capacity to achieve long term objectives including reduced hour-to-hour variability, or an improved match between hourly wind supply and electricity demand, can be achieved.



Diversifying with Offshore Wind and Other Renewables

The data presented in this poster relates to observed onshore wind speeds – the offshore wind resource, together with other renewable electricity generators such as wave, tidal and solar power, all offer opportunities for the UK to improve the reliability of renewable electricity supply through diversity.

The key to maximising the benefits of this diversity lie in understanding the patterns of availability of the different resources. For example, work carried out by the ECI on the UK's offshore wind resource has shown that offshore winds do not exhibit the same afternoon peak in wind speed that is apparent onshore.

Diversification is not restricted to wind power – while wave power shows a similar seasonal availability to wind power, differences in the hour to hour variability of the two resources means that there may be opportunities to reduce supply variability further by combining wind and wave power generation. Meanwhile, the supply patterns from the UK's tidal and solar resources are very different to wind, offering further opportunities to develop complementary renewable electricity resources.

The Environmental Change Institute is continuing research in this area, and will be presenting further findings on the potential for reliable renewable electricity supply.

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